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Differential Cross Sections of (α, α) and (α, α') Scattering from B^{11} , C^{12} , C^{13} , O^1 , Ne^{20} , Mg^{24} , Si^2 and P^{31}

AUTHOR(S):

Kokame, Jun; Fukunaga, Kiyoji; Nakamura, Hitoshi; Inoue, Nobuyuki

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Differential Cross Sections of (α, α) and (α, α') Scattering from B^{11} , C^{12} , C^{13} , O^{16} , Ne^{20} , Mg^{24} , Si^{28} and P^{31}

Jun Kokame*, Kiyoji Fukunaga*, Hitoshi Nakamura**
and Nobuyuki Inoue***

(Kimura Laboratory)

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Numerical differential cross sections of elastically and inelastically scattered alpha-particles are presented. Target nuclei are B^{11} , C^{12} , C^{13} , O^{16} , Ne^{20} , Mg^{24} , Si^{28} and P^{31} . The energy of the incident particles is about 28.5 Mev and the beam of alpha-particles was obtained from a 105 cm cyclotron of Kyoto University.

1. INTRODUCTION

Elastic and inelastic scattering of alpha-particles are useful reactions to investigate the structure of nuclear levels and the mechanisms of the scattering. Recently, the (α, α') scattering was intensively investigated by many researchers for intermediate nuclei ($A \sim 50$) in the vibrational region. According to the development in methods of analysis using electronic computers operated by a code of DWBA or other theories¹⁻⁴⁾, the excited states of the nuclei and the mechanism of the scattering have been successfully analyzed in many cases.

As the (α, α') scattering excites the nucleus preferentially in a collective mode, this property seems to be useful to investigate collective levels in light nuclei, because recent theoretical analyses show a considerable success in understanding levels in light nuclei by collective models as well as in heavy nuclei.

We have been investigating the (α, α') scattering of light nuclei, and the numerical values of differential cross sections of some nuclei obtained up-to-date are presented here with a brief description and discussion on each result.

2. EXPERIMENTAL PROCEDURES

An alpha-particle beam accelerated up to 28.5 MeV by a 105 cm F. F. cyclotron in our laboratory was brought to a 52 cm scattering chamber through a pair of quadrupole magnets. The energy spread of the beam is considered to be less than 150 keV.

Scattered alpha-particles were detected with a solid state detector, RCA C-4-250-2.0. A charge sensitive low noise preamplifier for the detector was designed and made by ourselves. Usual electronics were used to analyze the energy spectrum of scattered alpha-particles.

* 小 亀 淳, 福永清二

** 中 村 轟, Department of Physics, Faculty of Science, Kyoto University, Kyoto.

*** 井上 信幸, Present address: Institute of Plasma Physics, Nagoya University, Nagoya.

The target nuclei in the present results are B^{11} , C^{12} , C^{13} , O^{16} , Ne^{20} , Mg^{24} , Si^{28} and P^{31} .

For boron, a target was made by sedimentation of 96.7% enriched B^{11} powder on a thin gold backing of which thickness is 0.2 mg/cm². The thickness was estimated by weighing as 1.5 mg/cm².

For carbon (C^{12}), a self-supporting carbon foil was made by a cracking method⁵⁾ from methane gas. The thickness of the foil was 0.50 mg/cm². A Mylar film was also used.

The target of C^{13} was made by the cracking method using 56% enriched methane gas. The thickness was 0.38 mg/cm².

Natural gas of oxygen and neon were used for O^{16} and Ne^{20} in a gas target chamber in which the pressure was about 30 cmHg.

For magnesium, a foil of which thickness was 1.00 mg/cm² was made by evaporation in vacuum from metallic powder in natural abundance.

As a silicon target, unbacked silicon foil made by etching obtained from Toshiba Co. was used. This foil had relatively poor uniformity so that the absolute value of the measurement was calibrated by comparison with results obtained from SiO_2 -foils of which thickness were 3.25 and 2.14 mg/cm².

In last, a phosphorous target (3.50 mg/cm²) was made by sedimentation of red-phosphorous powder in alcohol on a thin gold foil.

3. RESULTS AND DISCUSSIONS

Numerical differential cross sections are shown in the following tables.

As the results and discussions had been reported elsewhere⁶⁻⁸⁾ in detail for each nucleus, here we discuss only on some interesting results.

3-1. Results on B^{11} , C^{12} and C^{13}

The yield from the second level (4.46 MeV, $5/2^-$) and the fourth level (6.76 MeV, $7/2^-$) in B^{11} are relatively large compared with that of the first and the third level. Their shapes of the angular distribution are quite close to each other.

These aspects can be understood reasonably by the unified model¹⁷ of the B^{11} nucleus, in which model the second and the third state are belonging to a rotational band of the ground state $K=3/2^-$. Thus the levels at 4.46 and 6.76 MeV seem to have collective nature and the relatively large yield.

As for the result for C^{12} , the scattering from the first excited state 2^+ , is interesting in comparison with inelastic scatterings from B^{11} . The latter nucleus can be considered alternatively by a model of the excited core^{8,18)}. In this model the four low-lying levels of B^{11} could be considered to the multiplet split out from the first excited state of C^{12} (the core nucleus) coupled to a hole of which spin is $3/2$ in the lp-orbit in the core. The both scatterings from B^{11} and C^{12} would have some resemblances in the shape of the angular distributions and their magnitude of the elastic and inelastic scattering. However, the experimental results show poor correspondence by each other so that the excited core model would be an over simplified model for such a light nucleus as boron.

As for C^{13} , the second excited state at 3.68 MeV ($3/2^-$) seems to be the first excited state of the ground-state rotational band with $K=1/2^-$.

There are two positive parity states nearby the level, namely 3.09 MeV ($1/2^+$) and 3.85 MeV ($5/2^+$). These levels had been understood as single particle levels having one nucleon in 2s- and 1d-shell respectively, because a large reduced width in the stripping reaction $C^{12}(d,p)C^{13}$ ⁹⁻¹¹⁾ had been obtained. In the latter reaction the yield leading the residual nucleus to the second level (3.68 MeV, negative parity) is small.

In (α, α') scattering, an enhanced excitation of collective levels can be expected. If the second state is actually collective, the yield from this level in the (α, α') scattering would be larger than that from other levels in contrast with the case of the stripping reaction. The result showed that the prediction is valid, and the second level of C^{13} seems to be a collective one belonging to the rotational band of the ground state.

3-2. Results on O^{16} , Ne^{20} , Mg^{24} and Si^{28}

These four nuclei, of which atomic numbers are $4n$ ($n=4,5,6$ and 7 , respectively), have low-lying levels of which the spin-parity is relatively well established¹²⁾. Among others, these nuclei have unnatural-parity states (e. g. 2^- , 3^+ etc.). The excitation of an unnatural-parity state of even-even nuclei by alpha-particles is very interesting to investigate the scattering mechanisms and the structure of the level, because the level can not be excited by ordinary direct interactions in a single step transition.

The experimental results show some appreciable yield from these unnatural-parity levels (2^- at 8.88 MeV in O^{16} and at 4.97 MeV in Ne^{20} ; 3^+ at 5.22 MeV in Mg^{24} and at 6.27 MeV in Si^{28}). The angular distributions show clear diffraction pattern. We are considering that the yields from these levels would be brought by a successive multiple excitations and/or an exchange process most probably (see detailed discussion in ref 6.).

For other levels of natural parity, the phase rule in Blair's inelastic diffraction scattering¹³⁾ seems to be fairly well satisfied with some exception. In general, a clear out-of-phase relation in the angular distribution was observed between the scattering from ground state (0^+) and the lowest excited level of 2^+ . Where the level has, or seems to have, odd spin-parity, the phase relation is in-phase.

The exception is 4^+ level, at 10.34 MeV in O^{16} , at 4.25 MeV in Ne^{20} and at 6.00 MeV in Mg^{24} . They show some systematic deviations from the phase rule and resemble to each other in the shape of the angular distribution. These facts are considered to be showing some common nature in the structure of the 4^+ levels in the light nuclei, but a clear explanation has not been made.

Some anomalously large yields were observed in Si^{28} (from a doublet at 6.88 MeV), contradicting current assignment of spin parities by the β - γ spectroscopy. The doublet (6.88 MeV and 6.89-MeV) is considered to consist of two states of 4^+ and 2^- ,¹⁶⁾ respectively. As mentioned above, the yield from unnatural-parity states is relatively small. The large cross section of the (α, α') scattering from the doublet should be considered to be mainly brought from the level of which spin is 4^+ . The yield from 4^+ levels are relatively small in other cases in light nuclei¹⁷⁾. Moreover the out-of-phase relation of the yield from this level to that

of ground state seems to inhibit an even parity to this level. Considering from relatively large yield and the phase relation, one of the doublet seems to prefer an negative parity and an odd number of spin, e. g. collective octupole vibration (3^-) from the result of the (α, α') scattering. However, the assignment of such a spin-parity has not been reported from experiments of β - γ decays.

3-3. The Result on P^{31}

Experiments of the (α, α') scattering from odd-A nuclei in the mass region 20 to 30 are relatively little. The nucleus P^{31} was investigated in the (α, α') scattering for comparison with the (p, p') scattering. The latter scattering had been intensively examined by our group in the energy region of 6.5~14 MeV^{14,15}.

The yields from the first excited level at 1.265 Mev ($3/2^+$) at angles of 32.5° to 45° were overlapped with that from carbon contaminations. The differential cross sections at these angles were obtained by a subtraction of contaminated peaks using the angular distribution of carbon measured separately at the same incident energy.

The integrated cross sections of α_1' and α_2' from 20° to 102.5° CM are 2.6 mb and 2.4 mb respectively of which errors are $\pm 10\%$. They have in-phase relation to each other and out-of-phase to the pattern of the elastic scattering.

The yield from the first and the second level in the (p, p') scattering resemble each other in the angular distribution as well as in the case of the (α, α') scattering. The integrated cross section of p_1' and p_2' are almost the same, but the former is slightly larger than the latter in the low energy regions and is smaller than the latter in higher regions.

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TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	28.3	0	3/2 -
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error* in mb/ster.	
20.4	137.1	1.1	
23.8	19.9	0.4	
27.1	69.1	0.4	
30.5	99.9	0.4	
33.8	95.4	0.4	
37.2	85.4	0.4	
40.5	27.1	0.2	
43.8	12.5	0.1	
47.0	6.13	0.10	
50.3	7.50	0.10	
53.5	8.82	0.10	
56.7	8.37	0.11	
59.9	5.92	0.08	
63.0	3.46	0.07	
66.2	1.66	0.04	
69.2	1.57	0.05	
72.3	2.86	0.05	
75.3	5.48	0.06	
78.3	6.97	0.09	
81.3	6.61	0.11	
84.2	5.74	0.10	
87.1	3.25	0.09	

*The statistical error.

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	28.3	-2.14	1/2 -
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
20.7	0.93	0.16	
24.1	0.792	0.079	
27.5	0.564	0.065	
30.9	0.582	0.067	
34.3	0.596	0.060	
37.7	0.801	0.054	
41.1	0.751	0.049	
44.4	0.670	0.032	
47.7	0.535	0.034	
51.0	0.425	0.037	
54.3	0.551	0.030	
57.5	0.510	0.029	
60.7	0.381	0.024	
63.9	0.191	0.022	
67.1	0.126	0.015	
70.2	0.207	0.027	
73.3	0.335	0.021	
76.4	0.514	0.029	
79.4	0.597	0.034	
82.4	0.425	0.044	
88.2	0.522	0.048	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	28.3	-4.46	5/2 -
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
21.1	10.4	0.3	
24.6	8.89	0.13	
28.1	6.81	0.12	
31.5	4.34	0.10	
35.0	3.37	0.09	
38.4	3.28	0.09	
41.8	3.18	0.08	
45.2	3.55	0.07	
48.6	3.22	0.08	
52.0	2.69	0.07	
55.3	1.93	0.06	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	28.3	-5.03	(1/2, 3/2) -
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
21.2	1.84	0.18	
24.7	1.92	0.11	
28.2	1.85	0.12	
31.7	1.57	0.10	
35.2	1.54	0.09	
38.6	1.28	0.07	
42.1	1.39	0.07	
45.5	1.22	0.06	
48.9	1.14	0.07	
52.2	1.55	0.08	
55.6	1.51	0.07	

$(\alpha, \alpha'), (\alpha, \alpha')$ Scattering from B^{11} , C^{12} , C^{13} , O^{16} , Ne^{20} , Mg^{24} , Si^{28} and P^{31}

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B^{11}	28.3	-6.76 -6.81	7/2 - (3/2 +)
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
21.6	7.35	0.21	
25.2	6.20	0.12	
28.7	4.44	0.10	
32.3	2.96	0.09	
35.8	2.90	0.09	
39.3	2.66	0.09	
42.8	2.68	0.08	
46.3	3.35	0.07	
49.7	2.60	0.08	
53.1	2.30	0.08	
56.5	2.14	0.06	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B^{11}	28.3	-7.30	(5/2 -)
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
21.7	1.59	0.19	
25.3	1.98	0.11	
28.9	1.76	0.10	
32.5	1.20	0.08	
36.0	1.12	0.08	
39.5	0.688	0.07	
43.1	0.692	0.07	
46.5	0.295	0.06	
50.0	0.306	0.05	
53.5	0.722	0.07	
56.9	0.347	0.06	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C^{12}	28.4	0	0 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
20.0	—	—	
23.3	—	—	
26.5	189.4	0.96	
29.8	274.8	1.2	
33.1	230.8	1.1	
36.3	167.5	0.8	
39.5	93.0	0.5	
42.8	45.8	0.4	
46.0	33.1	0.3	
49.2	38.3	0.3	
52.4	40.0	0.5	
55.5	34.0	0.3	
58.6	25.9	0.2	
61.7	15.8	0.08	
64.8	7.91	0.06	
67.8	2.86	0.05	
70.8	0.461	0.018	
73.8	0.740	0.026	
76.8	2.69	0.051	
79.7	4.99	0.067	
82.6	5.66	0.05	
85.4	5.32	0.08	
88.2	3.64	0.07	
91.0	1.60	0.05	
93.8	2.11	0.05	
96.5	3.31	0.14	
99.2	6.26	0.15	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C^{12}	28.4	-4.43	2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
20.6	24.8	0.6	
24.0	30.1	0.6	
27.4	22.9	0.4	
30.7	18.3	0.4	
34.1	14.4	0.4	
37.4	16.5	0.3	
40.8	21.4	0.4	
44.1	27.9	0.4	
47.4	31.2	0.4	
50.7	32.9	0.4	
53.9	27.8	0.4	
57.1	22.0	0.3	
60.3	18.6	0.3	
63.5	18.4	0.3	
66.7	22.4	0.4	
69.8	24.8	0.4	
72.9	25.7	0.4	
75.9	21.8	0.4	
78.9	16.8	0.3	
81.9	12.6	0.5	
84.8	10.5	0.3	
87.7	12.6	0.3	
90.6	17.1	0.3	
93.4	21.5	0.4	
96.2	21.8	0.4	
98.9	19.7	0.4	
101.6	13.7	0.2	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C ¹³	28.4	0	1/2 -
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
19.6	—	—	
22.8	—	—	
26.1	97.6	1.2	
29.3	196.4	1.6	
32.5	176.5	1.4	
36.6	76.5	1.2	
38.9	17.4	0.8	
42.0	9.24	0.58	
45.2	22.4	0.6	
48.3	29.1	0.6	
51.4	27.3	0.6	
54.5	17.9	0.6	
57.6	6.90	0.46	
60.6	3.82	0.36	
63.7	2.86	0.26	
66.6	3.89	0.19	
69.6	6.47	0.18	
72.6	9.77	0.22	
75.5	13.7	0.3	
78.4	15.7	0.3	
81.2	15.3	0.3	
84.0	10.8	0.3	
86.8	7.48	0.21	
89.6	6.29	0.19	
92.3	8.92	0.23	
95.0	13.6	0.3	
97.7	18.4	0.3	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C ¹³	28.4	-3.68 -3.85	3/2 - 5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
20.0	23.3	0.6	
23.3	17.9	0.4	
26.6	12.6	0.3	
29.9	7.14	0.27	
33.2	5.37	0.26	
36.5	7.41	0.23	
39.7	9.28	0.27	
42.9	9.17	0.23	
46.2	8.33	0.22	
49.4	5.50	0.20	
52.5	4.05	0.15	
55.7	3.49	0.14	
58.8	3.79	0.16	
61.9	4.28	0.16	
65.0	4.18	0.17	
68.0	4.23	0.17	
71.1	4.74	0.18	
74.0	5.52	0.19	
77.0	6.80	0.20	
79.9	7.38	0.20	
82.8	6.73	0.19	
85.7	4.97	0.16	
88.5	4.15	0.14	
91.3	3.77	0.14	
94.0	4.81	0.17	
96.7	6.91	0.20	
99.4	8.17	0.17	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C ¹³	28.4	-3.09	1/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
19.9	2.08	0.31	
23.2	2.75	0.22	
26.5	2.76	0.19	
29.8	2.92	0.21	
33.1	1.38	0.16	
36.3	0.81	0.13	
39.6	0.45	0.13	
42.8	1.03	0.12	
46.0	1.32	0.13	
49.1	2.00	0.14	
52.3	1.58	0.11	
55.4	1.45	0.11	
58.6	0.90	0.11	
61.6	0.441	0.078	
64.7	0.675	0.048	
67.7	1.58	0.14	
70.8	1.61	0.13	
73.7	1.41	0.13	
76.7	1.01	0.12	
79.6	0.500	0.099	
82.5	0.277	0.052	
85.3	0.161	0.029	
88.2	0.161	0.051	
90.9	0.205	0.047	
93.7	0.252	0.047	
96.4	0.275	0.059	
99.1	0.436	0.060	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C ¹³	28.4	-6.87	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
20.5	3.17	0.38	
23.9	4.35	0.33	
27.3	2.87	0.22	
30.7	2.19	0.18	
34.0	1.00	0.17	
37.4	0.99	0.13	
40.7	1.07	0.14	
44.0	0.99	0.12	
47.3	1.04	0.11	
50.6	0.71	0.11	
53.8	1.01	0.12	
57.0	0.92	0.11	
60.2	0.83	0.11	
63.4	1.15	0.12	
66.5	1.32	0.13	
69.6	1.15	0.13	
72.7	0.93	0.12	
75.7	0.86	0.13	
78.8	0.92	0.10	
81.7	0.91	0.11	
84.7	0.97	0.11	
87.6	1.01	0.11	
90.4	0.580	0.094	
93.2	0.722	0.093	
96.0	0.647	0.093	
98.7	0.427	0.088	
101.5	0.555	0.083	

(α, α), (α, α') Scattering from B¹¹, C¹², C¹³, O¹⁶, Ne²⁰, Mg²⁴, Si²⁸ and P³¹

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C ¹³	28.4	-7.50	3/2 +
		-7.55	
		-7.68	
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
20.7	18.0	0.6	
24.1	20.4	0.5	
27.5	17.7	0.3	
30.9	16.2	0.4	
34.3	11.5	0.3	
37.6	8.53	0.24	
41.0	6.89	0.23	
44.3	6.21	0.20	
47.6	5.24	0.19	
50.9	5.44	0.19	
54.2	4.79	0.17	
57.4	4.17	0.17	
60.6	3.95	0.18	
63.8	3.77	0.17	
67.0	4.94	0.18	
70.1	5.75	0.19	
73.2	7.02	0.21	
76.2	7.38	0.22	
79.3	6.35	0.21	
82.2	5.82	0.19	
85.2	4.46	0.17	
88.1	3.84	0.18	
91.0	4.07	0.18	
93.8	5.41	0.20	
96.6	5.94	0.23	
99.3	7.13	0.23	
102.0	7.52	0.18	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
O ¹⁶	27.3	(-6.06	0 +)*
		-6.14	3 -
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
19.4	13.5	0.4	
22.6	14.2	0.3	
25.8	13.6	0.2	
28.9	10.4	0.2	
32.1	7.91	0.17	
35.3	4.04	0.13	
38.4	1.92	0.09	
41.6	2.02	0.07	
44.7	2.92	0.08	
47.8	3.89	0.10	
50.9	4.37	0.09	
53.9	3.69	0.07	
57.0	3.56	0.07	
60.0	3.14	0.07	
63.0	3.37	0.07	
65.9	3.17	0.10	
68.9	3.27	0.09	
71.8	3.40	0.11	
74.7	2.84	0.10	
77.6	2.41	0.08	
80.4	1.88	0.06	
83.2	1.82	0.06	
86.0	1.87	0.06	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
O ¹⁶	27.3	0	0 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
18.7	176.3	1.2	
21.8	51.9	0.5	
24.9	93.5	0.5	
27.9	117.3	0.6	
31.1	89.9	0.52	
34.2	37.6	0.4	
37.2	7.81	0.17	
40.2	4.87	0.11	
43.2	16.4	0.2	
46.2	25.3	0.2	
49.2	25.7	0.2	
52.2	15.1	0.1	
55.2	8.18	0.03	
58.1	2.34	0.06	
61.0	0.549	0.029	
63.9	1.49	0.07	
66.8	3.64	0.09	
69.7	4.18	0.11	
72.5	3.49	0.10	
75.3	1.89	0.07	
78.1	0.825	0.040	
80.9	1.06	0.05	
83.6	2.02	0.06	
86.3	3.79	0.09	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
O ¹⁶	27.3	-6.92	2 +
		(-7.12	1 -)
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
19.5	12.5	0.4	
22.7	7.31	0.23	
25.9	4.92	0.16	
29.1	4.89	0.16	
32.3	6.62	0.16	
35.5	6.70	0.16	
38.7	5.87	0.15	
41.8	3.88	0.10	
45.0	2.62	0.08	
48.1	2.16	0.08	
51.2	2.55	0.07	
54.3	2.97	0.07	
57.3	3.29	0.07	
60.3	2.95	0.07	
63.4	2.63	0.06	
66.3	2.34	0.09	
69.3	2.62	0.08	
72.2	2.79	0.10	
75.1	3.36	0.10	
78.0	3.22	0.09	
80.9	2.82	0.08	
83.7	2.00	0.07	
86.5	1.56	0.06	

* Contributions from the level are considered to be small.

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
O ¹⁶	27.3	-8.88	2 -
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
19.8	4.68	0.37	
23.1	4.65	0.21	
26.3	3.21	0.14	
29.6	2.07	0.12	
32.8	1.10	0.10	
36.0	0.283	0.065	
39.2	0.338	0.060	
42.4	0.536	0.046	
45.6	0.875	0.055	
48.8	1.04	0.06	
51.9	0.849	0.050	
55.0	0.526	0.038	
58.1	0.281	0.031	
61.2	0.243	0.027	
64.2	0.210	0.018	
67.3	0.651	0.057	
70.3	0.795	0.055	
73.3	1.04	0.07	
76.2	0.895	0.060	
79.1	0.692	0.054	
81.9	0.333	0.039	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
O ¹⁶	27.3	-9.84 (-9.58)	2 + 1 -
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
19.9	2.24	0.32	
23.2	1.90	0.16	
26.5	1.89	0.12	
29.8	1.98	0.13	
33.1	2.47	0.13	
36.3	2.04	0.11	
39.6	1.62	0.09	
42.8	1.38	0.07	
46.0	1.03	0.07	
49.1	0.673	0.064	
52.3	0.594	0.051	
55.4	0.620	0.041	
58.6	0.811	0.042	
61.6	0.925	0.045	
64.7	0.780	0.046	
67.7	0.599	0.062	
70.8	0.391	0.053	
—	—	—	
76.7	0.210	0.054	
79.6	0.509	0.075	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
O ¹⁶	27.3	-10.34	4 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
20.1	0.824	0.256	
23.4	1.14	0.16	
26.7	1.38	0.14	
30.0	1.33	0.12	
33.3	1.27	0.11	
36.5	1.18	0.09	
39.8	0.903	0.085	
43.0	0.883	0.070	
46.3	1.16	0.08	
49.5	1.20	0.05	
52.7	0.921	0.058	
55.8	0.678	0.048	
58.9	0.355	0.035	
62.0	0.273	0.033	
65.1	0.202	0.033	
68.2	0.234	0.057	
71.2	0.397	0.059	
—	—	—	
77.2	1.77	0.11	
80.1	1.97	0.12	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Ne ²⁰	27.3	0	0 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
14.5	547.1	2.6	
18.0	209.0	1.0	
21.0	140.4	0.8	
23.9	175.3	0.9	
26.9	142.1	0.8	
29.9	55.0	0.3	
32.8	6.51	0.11	
35.7	5.94	0.10	
38.7	23.7	0.2	
41.6	33.7	0.3	
44.5	23.0	0.2	
47.4	10.3	0.1	
50.3	2.26	0.05	
53.1	0.877	0.032	
56.0	2.78	0.05	
58.8	4.27	0.07	
61.6	4.02	0.06	
64.4	2.51	0.05	
67.2	1.19	0.04	
70.0	0.573	0.022	
72.2	0.847	0.032	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Ne^{20}	27.3	-1.63	2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
15.1	30.1	0.8	
18.1	60.9	0.6	
21.1	47.0	0.5	
24.1	9.81	0.24	
27.1	4.16	0.20	
30.0	12.0	0.2	
33.0	19.5	0.2	
36.0	17.8	0.2	
38.9	10.2	0.1	
41.9	4.06	0.11	
44.8	2.61	0.09	
47.7	5.94	0.10	
50.6	9.23	0.10	
53.4	9.67	0.11	
56.3	6.81	0.08	
59.1	3.14	0.06	
62.0	1.19	0.03	
64.8	0.915	0.032	
67.6	1.72	0.04	
70.4	2.39	0.04	
73.1	2.39	0.05	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Ne^{20}	27.3	-4.25	4 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
18.3	2.06	0.18	
21.3	3.86	0.21	
24.3	3.29	0.19	
27.4	4.02	0.19	
30.4	3.04	0.11	
33.4	2.02	0.07	
36.4	1.34	0.06	
39.4	1.14	0.05	
42.3	1.02	0.07	
45.3	0.967	0.061	
48.2	0.686	0.040	
51.1	0.367	0.026	
54.0	0.232	0.023	
56.9	0.0934	0.0211	
59.8	0.274	0.021	
62.6	0.491	0.025	
65.4	0.778	0.031	
68.3	0.858	0.033	
71.1	0.807	0.026	
73.9	0.667	0.029	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Ne^{20}	27.3	-4.97	2 -
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
18.3	0.54	0.23	
21.3	0.41	0.12	
24.4	0.21	0.15	
27.5	0.41	0.11	
30.5	0.53	0.06	
33.5	0.87	0.06	
36.5	0.75	0.05	
39.5	0.46	0.04	
42.4	0.15	0.05	
45.4	0.10	0.04	
48.3	0.077	0.024	
51.3	0.18	0.02	
54.2	0.20	0.02	
57.1	0.26	0.03	
60.0	0.20	0.02	
62.8	0.18	0.02	
65.7	0.26	0.02	
68.5	0.28	0.02	
71.3	0.31	0.02	
74.1	0.33	0.03	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Ne^{20}	27.3	-5.63 (-5.80)	3 - (1 -)
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
18.4	7.39	0.37	
21.5	9.88	0.28	
24.5	9.17	0.26	
27.6	8.41	0.24	
30.6	4.55	0.13	
33.6	2.14	0.09	
36.6	1.41	0.07	
39.6	1.81	0.07	
42.6	2.48	0.10	
45.6	2.44	0.09	
48.5	1.72	0.06	
51.5	1.34	0.05	
54.4	1.47	0.05	
57.3	1.72	0.05	
60.2	2.04	0.05	
63.1	1.91	0.05	
65.9	1.74	0.05	
68.7	1.03	0.04	
71.5	0.969	0.032	
74.3	0.888	0.040	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁴	28.4	0	0 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
23.3	252.3	0.5	
26.1	193.2	0.7	
29.0	114.4	0.4	
31.9	18.9	0.2	
34.8	10.1	0.1	
37.6	39.4	0.2	
40.5	52.2	0.3	
43.3	35.3	0.2	
46.2	15.9	0.1	
49.0	3.60	0.04	
51.8	3.54	0.04	
54.6	8.70	0.05	
57.3	10.8	0.1	
60.1	8.24	0.05	
62.9	3.98	0.03	
65.6	1.12	0.02	
68.3	0.636	0.010	
71.0	1.56	0.02	
73.7	2.35	0.03	
76.4	2.20	0.02	
79.1	1.46	0.03	
81.6	0.792	0.019	
84.3	0.578	0.016	
86.9	0.838	0.013	
89.5	1.29	0.02	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁴	28.4	-1.368	2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
23.4	13.1	0.2	
26.3	6.02	0.16	
29.2	14.2	0.2	
32.1	22.3	0.2	
34.9	18.8	0.1	
37.8	9.60	0.07	
40.7	3.35	0.09	
43.5	3.61	0.08	
46.3	6.70	0.07	
49.2	10.3	0.1	
52.0	9.55	0.06	
54.8	5.88	0.04	
57.6	2.45	0.02	
60.3	1.28	0.02	
63.1	1.83	0.02	
65.8	2.55	0.02	
68.6	2.83	0.02	
71.0	2.31	0.02	
73.5	1.22	0.02	
76.4	0.556	0.011	
79.3	0.536	0.017	
81.9	0.769	0.019	
84.6	1.04	0.02	
87.2	1.02	0.01	
89.7	0.934	0.020	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁴	28.4	-4.12 -4.23	4 + 2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
23.6	4.43	0.08	
26.5	4.36	0.09	
29.4	4.51	0.08	
32.4	5.00	0.09	
35.3	5.01	0.08	
38.1	3.78	0.06	
41.0	2.85	0.07	
43.9	1.59	0.04	
46.8	1.42	0.04	
49.6	1.79	0.04	
52.4	1.94	0.03	
55.3	1.96	0.03	
58.1	1.46	0.02	
60.9	0.946	0.020	
63.6	0.606	0.015	
66.3	0.696	0.017	
69.1	0.984	0.013	
71.8	1.26	0.017	
74.6	1.28	0.02	
77.2	0.922	0.015	
79.9	0.842	0.023	
82.6	0.917	0.022	
85.2	1.04	0.02	
87.8	1.19	0.02	
90.4	1.18	0.02	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁴	28.4	-5.22	3 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
23.7	1.33	0.04	
26.6	1.20	0.04	
29.6	0.949	0.033	
32.5	0.466	0.018	
35.4	0.370	0.035	
38.3	0.553	0.028	
41.2	0.569	0.041	
44.1	0.505	0.027	
47.0	0.400	0.029	
49.8	0.315	0.022	
52.7	0.265	0.019	
55.5	0.293	0.017	
58.3	0.245	0.015	
61.1	0.198	0.009	
63.9	0.139	0.012	
66.6	0.0677	0.0104	
69.4	0.103	0.007	
72.1	0.169	0.010	
74.8	0.213	0.012	
77.5	0.164	0.005	
80.2	0.278	0.012	
82.8	0.241	0.013	
85.5	0.187	0.013	
88.1	0.106	0.008	
90.7	0.118	0.011	

$(\alpha, \alpha'), (\alpha, \alpha')$ Scattering from B^{11} , C^{12} , C^{13} , O^{16} , Ne^{20} , Mg^{24} , Si^{28} and P^{31}

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg^{24}	28.4	-6.00	4 +	Mg^{24}	28.4	-6.44	0 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.		θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
23.8	2.55	0.08		23.8	2.67	0.07	
26.7	2.17	0.09		26.8	1.31	0.06	
29.7	2.19	0.06		29.7	1.48	0.06	
32.6	1.73	0.07		32.7	1.74	0.07	
35.5	1.04	0.05		35.6	1.05	0.05	
38.4	1.09	0.04		38.5	0.776	0.035	
41.3	1.25	0.06		41.4	0.395	0.054	
44.2	—	—		44.3	—	—	
47.1	0.810	0.047		47.2	—	—	
49.8	0.628	0.030		50.1	0.531	0.019	
52.8	0.484	0.019		52.9	—	—	
55.7	0.295	0.016		55.8	0.295	0.019	
58.5	0.179	0.012		58.6	—	—	
61.3	0.223	0.014		61.4	0.0927	0.0122	
64.1	0.324	0.014		64.2	0.0541	0.0100	
66.8	0.434	0.016		67.0	0.0675	0.0115	
69.6	0.605	0.013		69.7	0.144	0.009	
72.3	0.648	0.017		72.5	0.176	0.013	
75.0	0.483	0.017		75.2	0.141	0.012	
77.7	0.372	0.011		77.9	0.110	0.009	
80.4	0.275	0.019		80.6	0.0616	0.0098	
83.1	0.245	0.015		83.2	0.0330	0.0083	
85.7	0.240	0.014		85.9	0.0255	0.0072	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Si^{28}	28.3	0	0 +	Si^{28}	28.3	-1.772	2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.		θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
17.1	936.3	6.2		14.3	117.2	2.0	
20.0	448.2	4.3		17.2	61.9	1.1	
22.8	463.4	1.8		20.1	35.8	0.8	
25.7	296.0	1.0		22.9	12.8	0.3	
28.5	109.2	0.5		25.8	5.86	0.15	
31.3	19.8	0.2		28.6	12.3	0.2	
34.1	21.1	0.2		31.5	20.3	0.4	
36.9	56.6	0.4		34.3	16.9	0.2	
39.7	63.5	0.4		37.1	9.10	0.20	
42.5	35.0	0.3		39.9	4.25	0.10	
45.2	11.8	0.2		41.3	3.21	0.09	
48.0	1.46	0.04		42.7	4.07	0.09	
50.8	5.91	0.09		45.5	6.33	0.12	
53.6	11.7	0.1		48.3	7.57	0.10	
56.3	12.9	0.1		51.0	5.94	0.08	
59.0	8.72	0.10		53.8	3.26	0.07	
61.7	3.53	0.06		56.5	2.17	0.05	
64.4	0.848	0.025		59.3	1.99	0.05	
67.1	0.698	0.023		62.0	2.79	0.05	
69.8	1.56	0.03		64.7	3.06	0.05	
72.4	2.28	0.04		67.4	3.11	0.05	
75.1	2.11	0.04		70.1	2.71	0.05	
77.7	1.30	0.03		72.7	2.10	0.04	
80.3	0.686	0.023		75.4	1.05	0.03	
82.9	0.461	0.017		78.0	0.740	0.024	
				80.6	0.736	0.024	
				83.2	1.23	0.03	
				85.8	1.69	0.03	
				88.4	1.73	0.04	
				91.0	1.29	0.03	
				93.5	0.719	0.024	
				96.0	0.536	0.018	
				98.5	0.885	0.025	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Si ²⁸	28.3	-3.61 -4.97	4 + 0 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
17.4	—	—	
20.2	—	—	
23.1	—	—	
26.0	2.14	0.14	
28.8	2.32	0.09	
31.7	2.36	0.09	
34.6	2.23	0.09	
37.4	1.82	0.08	
40.2	1.30	0.07	
43.0	1.09	0.06	
45.8	1.10	0.06	
48.6	1.25	0.04	
51.4	1.38	0.05	
54.2	1.09	0.04	
56.9	0.879	0.040	
59.7	0.891	0.038	
62.4	0.985	0.034	
65.2	1.15	0.03	
67.9	1.17	0.03	
70.6	0.990	0.030	
73.2	0.717	0.026	
75.9	0.574	0.024	
78.5	0.623	0.025	
81.2	0.841	0.030	
83.8	1.02	0.03	
86.4	1.03	0.03	
89.0	0.749	0.027	
91.5	0.609	0.023	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Si ²⁸	28.3	-6.88 -6.89	2 - & 4 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
17.5	19.0	0.8	
20.4	18.4	0.7	
23.2	15.8	0.4	
26.1	11.5	0.3	
29.0	7.18	0.15	
31.9	5.83	0.15	
34.7	5.04	0.14	
37.6	6.27	0.15	
40.4	6.28	0.15	
43.3	5.19	0.12	
46.1	3.33	0.09	
48.9	1.89	0.06	
51.7	1.66	0.06	
54.5	1.28	0.06	
57.3	1.71	0.06	
60.1	1.72	0.07	
62.8	1.33	0.05	
65.5	1.12	0.04	
68.2	0.830	0.040	
70.9	0.969	0.040	
73.6	1.12	0.04	
76.3	1.47	0.05	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Si ²⁸	28.3	-6.27	3 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
17.5	0.527	0.432	
20.4	0.698	0.691	
23.2	0.909	0.382	
26.1	0.417	0.213	
29.0	0.278	0.158	
31.9	0.369	0.248	
34.7	0.301	0.160	
37.6	0.445	0.193	
40.4	0.466	0.149	
43.3	0.408	0.230	
46.1	0.248	0.171	
48.9	0.127	0.057	
51.7	0.114	0.072	
54.5	0.139	0.057	
57.3	0.202	0.055	
60.1	0.164	0.064	
62.8	0.112	0.041	
65.5	0.0919	0.0404	
68.2	0.0451	0.0298	
70.9	0.0478	0.0292	
73.6	0.106	0.042	
76.3	0.157	0.042	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	28.3	0	1/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
22.6	138.8	0.2	
25.4	105.1	0.2	
28.2	36.3	0.3	
31.0	8.37	0.05	
33.7	12.6	0.1	
36.5	19.5	0.1	
39.3	17.7	0.1	
42.1	8.96	0.05	
44.8	2.60	0.03	
47.6	0.913	0.012	
50.3	2.86	0.03	
53.0	3.92	0.03	
55.7	3.68	0.04	
58.4	1.29	0.02	
61.1	0.257	0.009	
63.8	0.219	0.006	
66.5	0.607	0.010	
69.1	0.845	0.011	
71.8	0.670	0.010	
74.4	0.366	0.008	
77.0	0.143	0.005	
79.6	0.148	0.004	
82.2	0.304	0.006	
—	—	—	
87.4	0.501	0.007	
—	—	—	
92.5	0.351	0.006	
—	—	—	
97.5	0.211	0.004	
—	—	—	
102.5	0.117	0.003	

$(\alpha, \alpha'), (\alpha, \alpha')$ Scattering from B^{11} , C^{12} , C^{13} , O^{16} , Ne^{20} , Mg^{24} , Si^{28} and P^{31}

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P^{31}	28.3	-1.256	3/2 +	P^{31}	28.3	-2.232	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.		θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
22.5	4.15	0.05		22.4	1.97	0.04	
25.3	4.37	0.06		25.2	1.28	0.02	
28.1	2.36	0.08		28.0	2.02	0.02	
30.9	1.57	0.04		30.7	2.07	0.02	
33.6	0.835	0.04		33.5	1.31	0.02	
36.4	0.797	0.030		36.3	0.573	0.013	
39.2	1.13	0.03		39.0	0.334	0.018	
41.6	1.29	0.04		41.8	0.451	0.019	
44.7	1.27	0.04		44.5	0.640	0.021	
47.4	0.426	0.008		47.3	0.429	0.008	
50.1	0.272	0.009		50.0	0.314	0.021	
52.9	0.115	0.006		52.7	0.114	0.010	
55.6	0.159	0.007		55.4	0.125	0.007	
58.3	0.187	0.006		58.1	0.288	0.015	
61.0	0.253	0.009		60.8	0.354	0.010	
63.6	0.199	0.006		63.4	0.329	0.007	
66.3	0.130	0.005		66.1	0.250	0.006	
68.9	0.0630	0.0031		68.7	0.139	0.005	
71.6	0.0438	0.0026		71.4	0.0895	0.0038	
74.2	0.0619	0.0032		74.0	0.0741	0.0035	
76.8	0.0790	0.0036		76.6	0.0839	0.0038	
79.4	0.0638	0.0026		79.2	0.0909	0.0031	
82.0	0.0456	0.0029		81.8	0.0938	0.0033	
—	—	—		—	—	—	
87.2	0.0260	0.0015		86.9	0.0730	0.0025	
—	—	—		—	—	—	
92.2	0.0484	0.0021		92.0	0.0742	0.0026	
—	—	—		—	—	—	
97.3	0.0421	0.0020		97.0	0.0809	0.0027	
—	—	—		—	—	—	
102.2	0.0985	0.0030		102.0	0.1025	0.0031	

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